BIOPSY CLIPS: CHALLENGES TO QUANTITATIVE BREAST MRI

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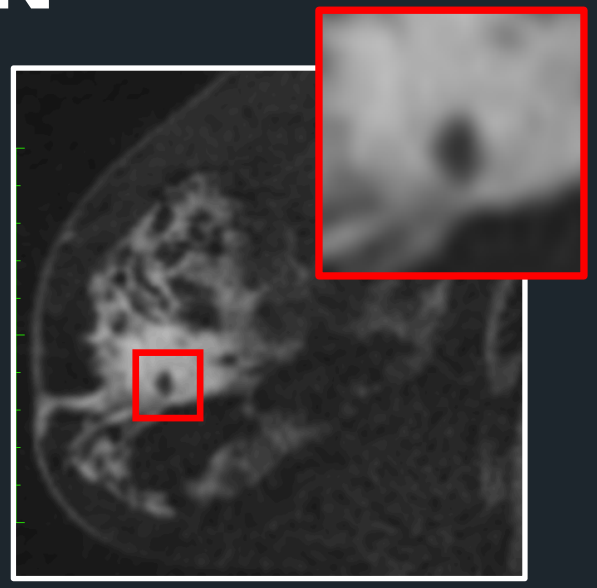
INTRODUCTION

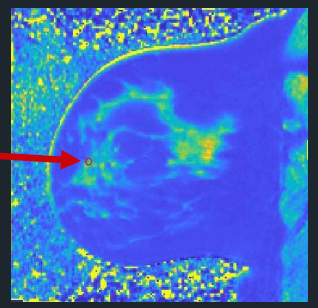
- At biopsy, metallic clips left in lesion to mark biopsy location
- At 1.5T, image signal void artifact is 2-6 x larger than metallic clip size[1]
- Outside void artifact, field inhomogeneities interfere with T_1 measurement

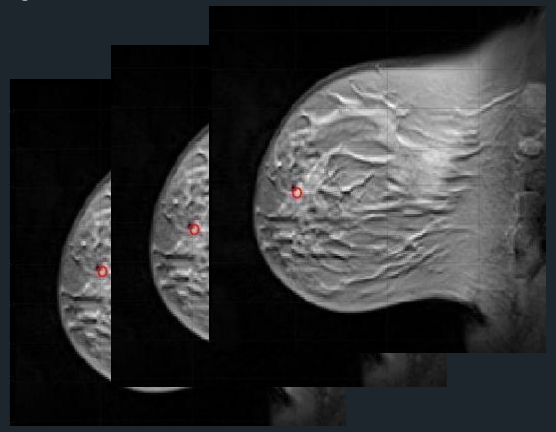
(critical for quantitative DCE-MRI)

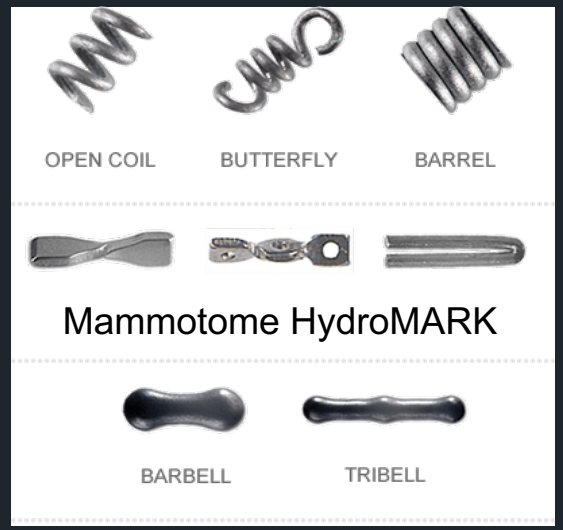


Clips affect T_1 maps used to quantify DCE-MRI

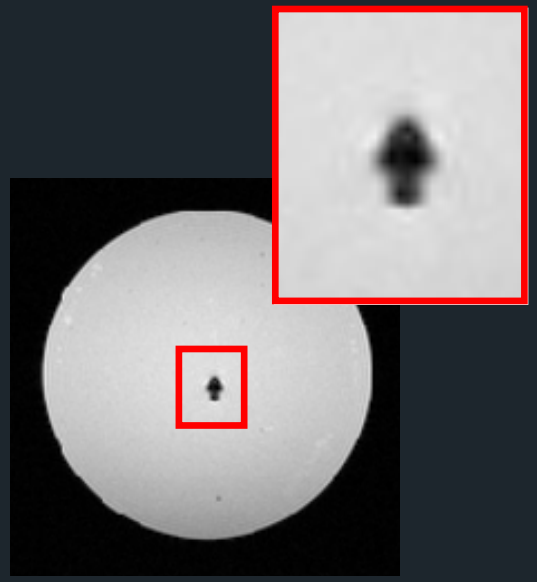
T_{10}

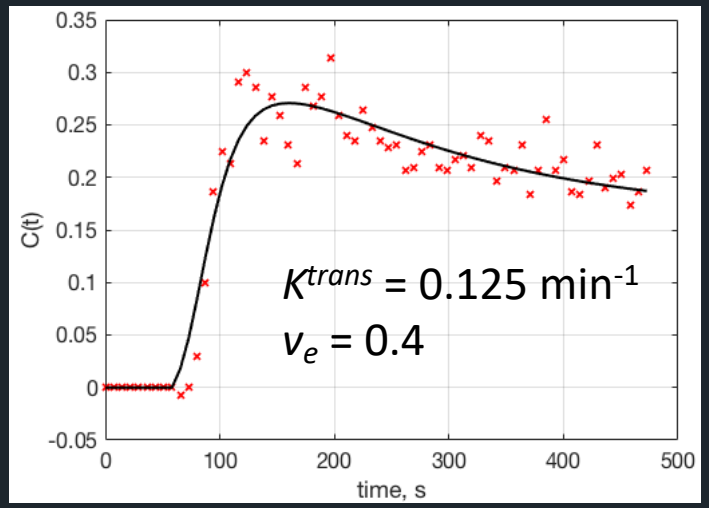






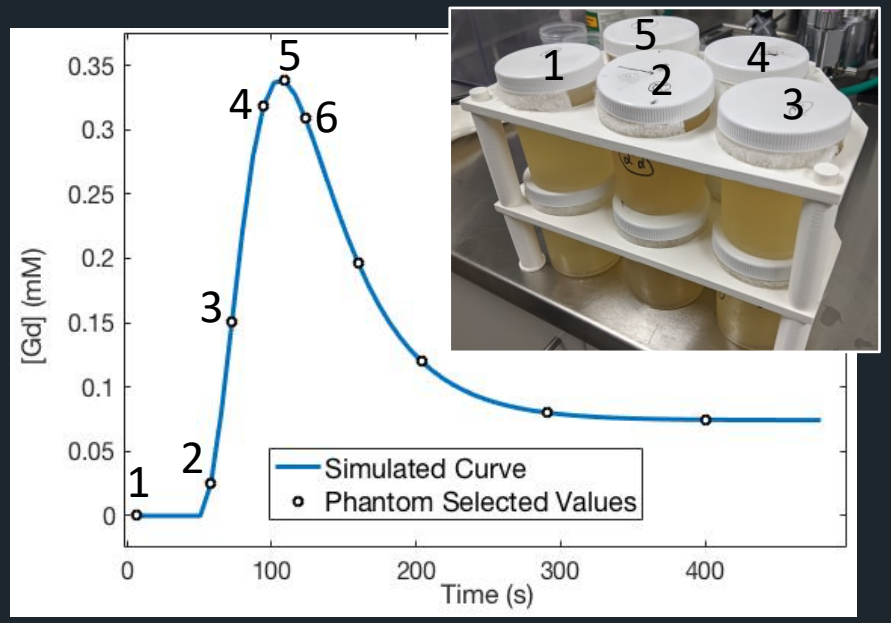
2-3 mm





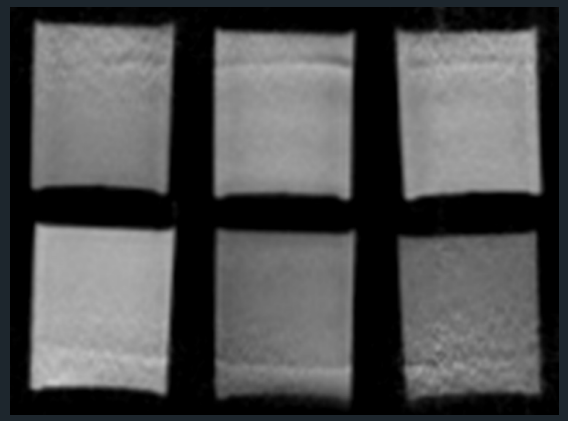
METHODS

- We created sets of 10 gelatin phantoms with varying amounts of gadolinium contrast agent
- Contrast agent concentrations were selected to mimic values traced along a simulated concentration curve with Kety-Tofts model parameters of K^{trans} 0.2 min^{-1} and v_e fraction of 0.1:

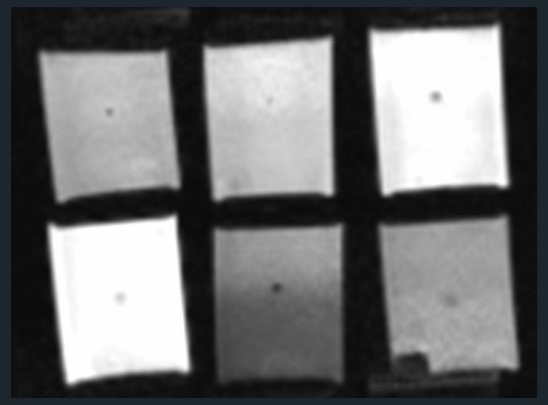


Set simulates a curve in a single phantom, as if concentration were increased in a spatially uniform manner

No clip phantom set



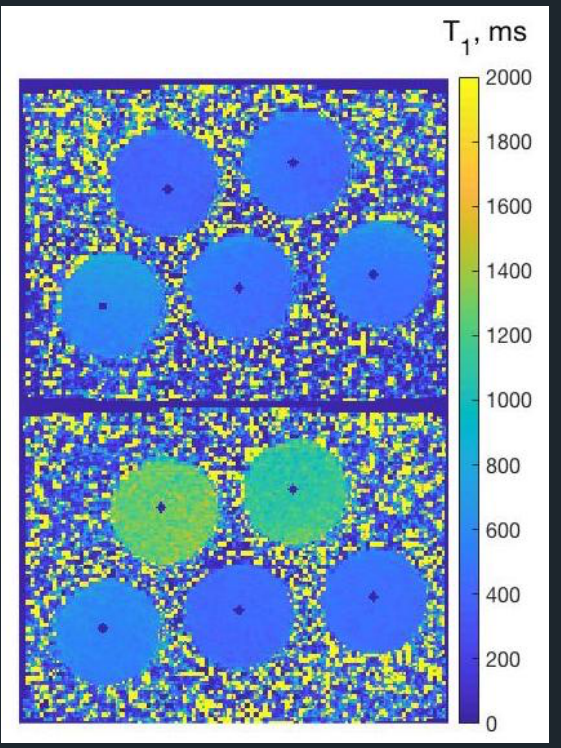
Clip phantom set



Phantoms were scanned with a Siemens 3T Skyra scanner and 4-channel flex coil for:

- Rapid B_1 mapping using TurboFLASH with pre-conditioning RF Pulses[2]
- T_1 maps using a multi-flip angle sequence[3] with:
  - 10 flip angles (2 - 20 degrees)
  - resolution 1.25 x 1.25 x 4 mm^3
- K^{trans} and v_e parameters were computed using the Kety-Tofts model:

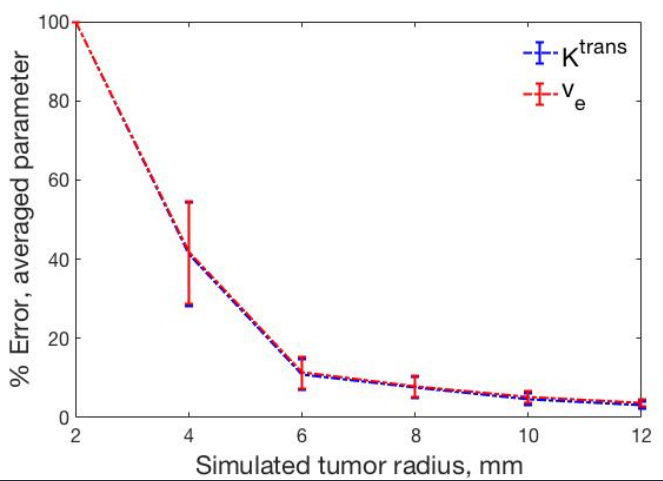
$$C_t(T) = K^{\text{trans}} \bullet \int_0^T C_p(t) \cdot \exp\left(-\frac{K^{\text{trans}}}{v_e} \cdot (T-t)\right) \mathrm{dt}$$



RESULTS

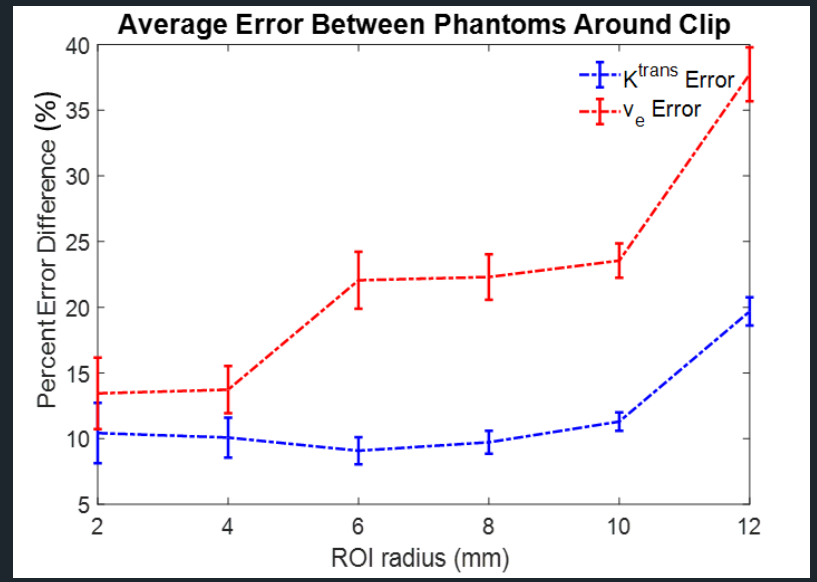
Simulating clip artifacts

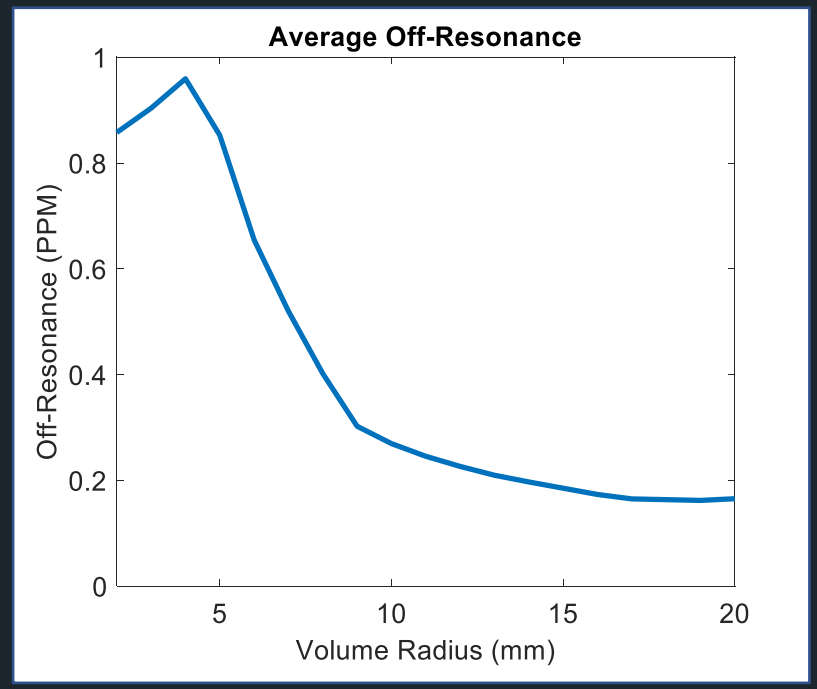
- We zeroed the signal in the first 2-mm around the center of no-clip phantoms, and created DCE-MRI parameter maps with the simulated-clip scans
- Circular regions of interest (ROIs) of increasing radius (4-12 mm) are segmented to simulate averaging over different-sized tumors



Imaging artifacts in clip phantoms

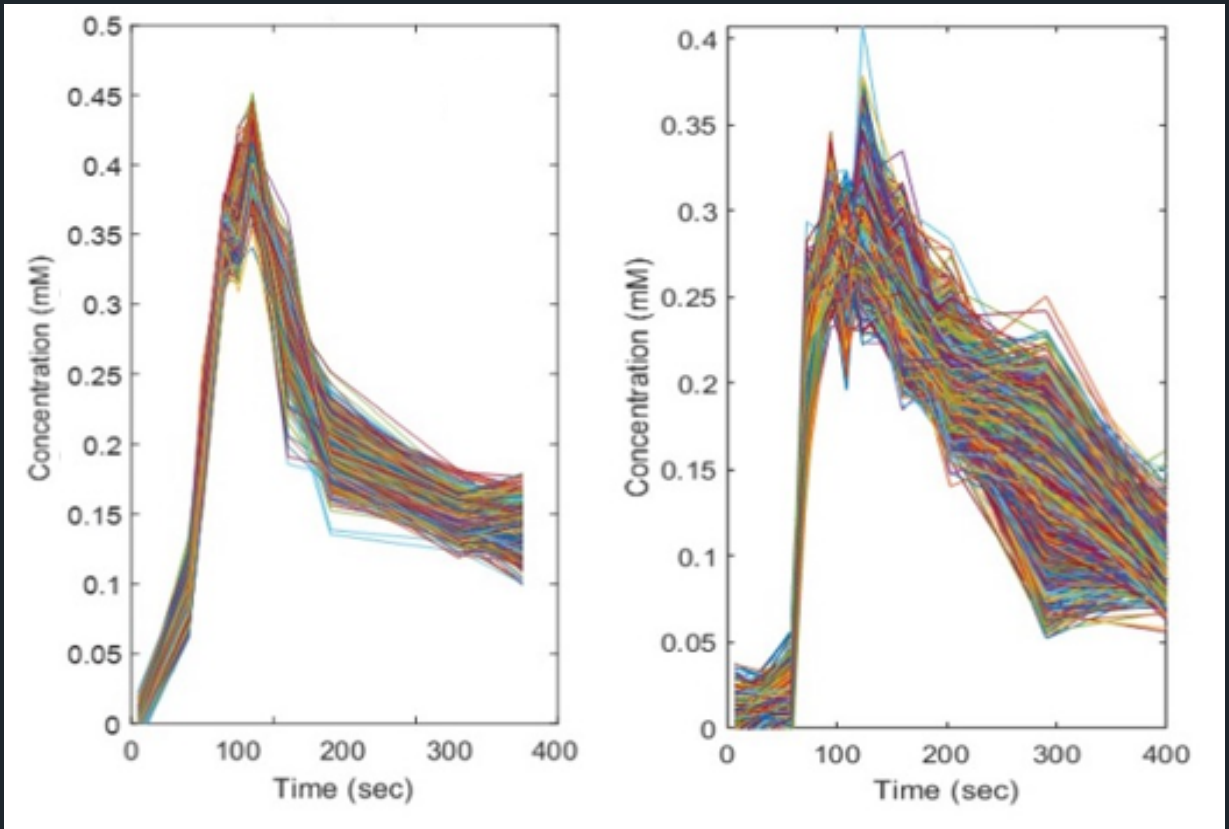
- We imaged similar clip and no-clip phantoms with two different echo times for measuring the off-resonance from magnitude and phase raw data
- Circular ROIs of increasing radius were again segmented to simulate averaging over different-sized tumors
- Error remained high outside the radius of signal void artifact around the clip
- Off-resonance was measured to 0.2 PPM at the max measured radius





Scanned phantoms with and without clips

No clips: **Clips in each:**



Simulated uptake curves result in averaged fit parameters:

- No-clip phantom scans:
  K^{trans} of 0.19 min^{-1} and v_e fraction of 0.14
- clip-embedded phantom scans:
  K^{trans} of 0.11 min^{-1}, v_e fraction of 0.11

CONCLUSIONS

- Biopsy marker clips create phase errors that affect quantitative DCE-MRI
- Off-resonance errors due to clips are suspected to be more problematic when imaging smaller tumors
- Artefacts are difficult to correct in patient data because signal void prevents the clip shape/orientation from being observed

REFERENCES

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[2] Chung S, et al. Rapid B1+ mapping using a preconditioning RF pulse with TurboFLASH readout. Magn Reson Med. 2010 Aug;64(2):439-46.

[3] Sorace AG, et al. Repeatability, reproducibility, and accuracy of quantitative MRI of the breast in the community radiology setting. J Magn Reson Imaging. 2018 Mar 23:10.